SAFESPUR Forum

Long Term Trends in Groundwater Quality and Groundwater Sampling Techniques

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Presentation Outline

- Time dependent variability.
- Time independent variability.
- Importance of understanding data variability.
- Available options for groundwater sampling.
- Which sampling method do I choose?
- Selected measures to help reduce variability arising from groundwater sampling.

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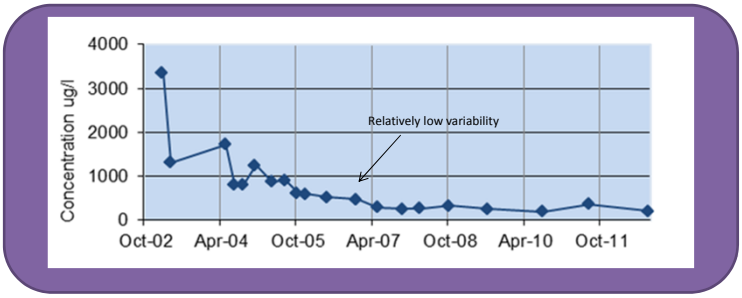
Time Dependent Variability

- Primary goal of Long Term Monitoring is to identify long term temporal ("time dependent") trends in contaminant concentrations.



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Time Dependent Variability

- Long term changes can be a function of:
  - reduction in average long term source strength;
  - changes in the attenuation capacity of the aquifer (dilution, adsorption and biodegradation);
  - introduction of new sources of contamination (e.g. buried drum wastes in landfill sites or a new leak); and
  - long term change in hydrogeological conditions – groundwater recharge patterns and groundwater levels.
- Sometimes but not always this long term trend is masked by "time independent data".

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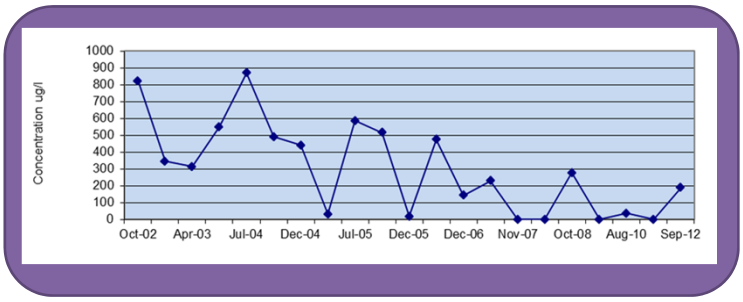
Time Independent Variability

- Monitoring records often have considerable "noise", "random variability", "scatter" or "time independent" variability. Sometimes this is minor or moderate:



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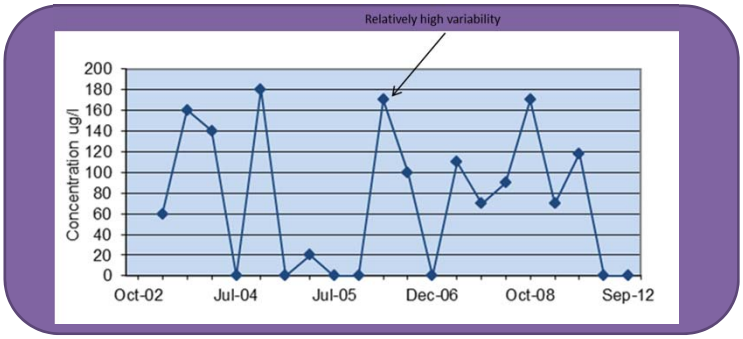
Time Independent Variability

- Sometimes this is large and makes data interpretation very difficult or impossible:



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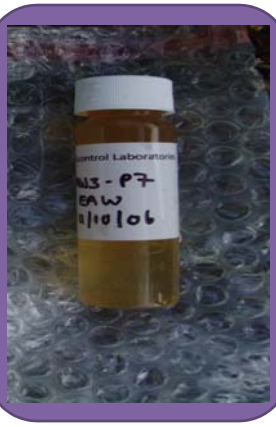
Time Independent Variability



Time independent variability arises from: Monitoring Well, Hydrogeological & Contaminant Characteristics:

- Length of screen;
- Permeability variations;
- Contaminants being monitored (e.g. DNAPLs);

Operator Elements:

- Sampling methods (e.g. fixed volume v low flow sampling);
- Sample collection (how do you fill up a vial?);
- Preservation/filtering techniques;
- Sample transfer (keeping the samples cool, delivery to the laboratory); and
- Chemical analysis (e.g. bias introduced by laboratories).

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Importance of Understanding Data Variability

- Makes it difficult to interpret data;
- May increase costs associated with more intensive monitoring to compensate for variability;
- May increases costs required to evaluate groundwater remediation such as MNA, ISCO etc; and
- Often more difficult to gain Regulator approval……..

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Some Surprising Findings from a US Study

- One of the few studies looking at variability in groundwater monitoring data sets concluded that for VOC data analysed:
  - monitoring frequencies of more than one event per year serves primarily to characterise time independent variability and not LTM goals;
  - long term concentration trend accounts for only 30 to 40% of monitoring variability (spend less?);
  - aquifer and well specific factors are an important source of monitoring variability; and
  - laboratory bias in the sample data of +/- 20% (and was not identified from field duplicates).

Ref: GWM&R 31, No. 2, Spring 2011, Pages 92 to 101.

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Variability in Groundwater Monitoring Data

- A better understanding of variability will help:
  - implement measures to reduce such variability;
  - reduce the amount of monitoring data needed to identify long term trends;
  - support sampling methods for specific well designs or hydrogeological conditions; and ultimately
  - facilitate more efficient LTM programmes.

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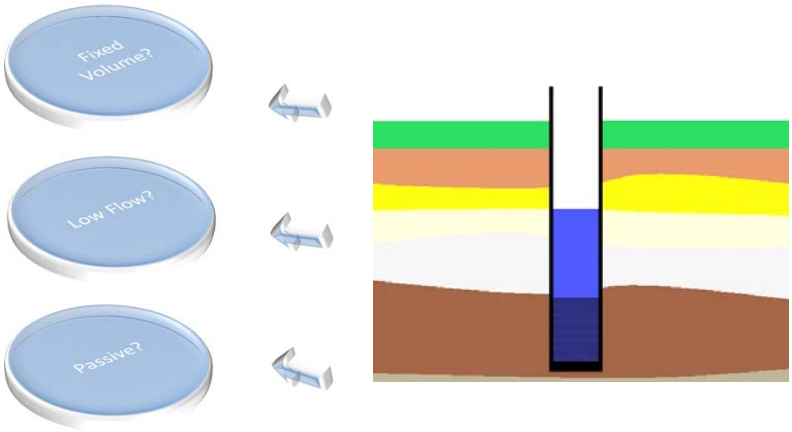
Available Options for Groundwater Sampling



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Sampling Methods

- Traditional method.
- Involves removing a fixed volume of water from the column- usually 3 well volumes.
- Simple pumps and bailers.
- Time consuming.
- Labour intensive.

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Sampling Methods

- Water is removed from the screened intake at a very low rate.
- Water quality is monitored for stability.
- Bladder and peristaltic pumps.
- High set up cost.
- Can be used for VOCs.
- Short screen wells.

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Sampling Methods

- Newest method.
- A discrete sample is taken from a specific location in the column.
- Grab samplers and diffusion samplers.
- Most cost effective way of sampling when you consider time.
- Short screens.
- Can be used for VOCs.
- Widely used in North America.
- No purge water to dispose of.

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Passive Samplers - Hydrasleeve

- Hydrasleeve samplers can be used to take samples from a specific interval/zone in a well.
- Sometimes described as a 'grab sampler'.
- The Hydrasleeve fills up over one and a half times it length.
- No sample mixing occurs due to the specialist valve on the sampler.

- You can freeze the Hydrasleeve to sample below a product layer.
- Multiple samplers can be tethered in order to profile a borehole.
- Hydrasleeve samplers can be used to sample below a product layer.
- The Hydrasleeve is frozen into a block of ice. It thaws in the borehole and then you can take your sample.

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Passive Samplers – Equilibrator

- The Equilibrator is a passive diffusion bag style sampler.
- Used for specific VOCs (list available).
- The sampler is filled with deionised water and installed in the borehole.
- Over a period of two weeks the sample will equilibrate.
- Great for low yield boreholes.

- The sample chamber is semi permeable which allows VOCs to diffuse into the sampler until the concentration gradient equilibrates between the sampler and the water column.
- The sample can be dispensed straight into a VOC vial.
- Can be used for surface water.

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Low Flow– The Future

- The most commonly used low flow pumps are bladder pumps and peristaltic pumps.
- Water quality instruments and a flow cell are used to monitor pH, ORP, EC, Temperature and Dissolved Oxygen.
- A series of separate meters or a multi parameter can be used.

- New developments mean there is now low flow water quality equipment available that can be operated using a smartphone via Bluetooth.
- The unique App notifies you once the water quality has stabilised and formats a report which can be e-mailed directly to the office.

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Novel Sampling Techniques

- There are a wide range of alternatives to traditional methods.
- Most research on the newer techniques has been completed in the US on short screen wells.
- Passive and Low Flow methods are more cost effective in terms of labour.
- If you know your borehole chemistry it could be possible to use passive and low flow methods in longer screened wells.
- Passive and low flow sampling can provide great data for VOCs due to minimal disturbance during sampling.

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Which Sampling Method do I Choose?

- Ultimately choose methods, taking into account site specific conditions that achieve LTM goals.
- Refer to relevant guidance on groundwater sampling.

Note:

- Relevant guidance includes: LFTGN02 (2003); BS ISO 5667-11 (2009); ASTM D4448-01 (2013) and D6452 (2012); and ITRC overview of Passive Sampling (2006).
- No BS standard for passive sampling techniques (albeit on a site by site basis it has received regulatory acceptance).
- No definitive guidance assessing methods, pollutants, and well design and hydrogeological conditions – factors subject to a PHD Study sponsored by Waterra In-Situ.
- From experience EA preference is for low flow sampling.
- International perspective – what happens elsewhere?

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Selected measures to help reduce variability arising from groundwater sampling

- Use UK and international guidance where applicable but be wary of BS ISO 5667-11 that suggests that low flow sampling is most suited to well designs with long screen lengths (p18) – this may not be the case.
- Consider characterise inflow and outflow zones e.g. by profiling with passive sampling techniques or in-borehole tracer tests.
- If you do change sampling methods - overlap them so differences can be identified.
- Be aware that PDBs are not suitable for all VOCs.
- HydraSleeves – use appropriate stabilisation times before sample collection (minimum 30minutes – longer the better).

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In Summary:

- Groundwater data variability is an important consideration for long term groundwater monitoring, particularly when you cannot remove the contaminant source and for controlling costs.
- There are readily available sampling methods, that if used appropriately, can be used to minimise data variability.
- By achieving a streamlined and efficient LTM plan with minimal data independent variability, there will be more chance of achieving regulatory approval.

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Some useful references on statistics comprise:

– Gibb Robert D. 2009. Statistical Methods for Groundwater Monitoring. Second Edition.
– March 2009. USEPA. Statistical Analysis of Groundwater Monitoring Data at RCRA Facilities – Unified Guidance

Thank you for listening. Any Questions?

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